

Totality begins at Mergui at . . . 2h. om. 6s. local time.

Duration	...	...	4m. 6s.
Sun's altitude	...	...	61°

Totality begins at Tenasserim at 2h. 2m. 7s. local time.

Duration	...	...	3m. 57s.
Sun's altitude	...	...	60°

Nearly midway between the above places, or where a "Conical Peak" is marked on the Admiralty Chart, the total eclipse continues 4m. 14s.

"Bangkok (Siam) will be found to lie rather north of the central line. The circumstances of the eclipse at this point are as follows (long. 6h. 42m. 6s. E.; lat. 13° 42' 5" N.)

"The partial eclipse begins at oh. 51m. 6s. mean time at Bangkok, 134° from the north point towards the west, and 168° from the vertex eastward, for *direct* image; the sun at an altitude of 76°. The total eclipse begins at 2h. 13m. 7s. and continues 3m. 54s., the sun about 57° high, and the partial phase ends at 3h. 33m.

"The invitation extended to British and other astronomers by the King of Siam, to observe this interesting and important phenomenon within his dominions, may be expected to bring together a number of competent observers in the vicinity of Bangkok; and in selecting localities for astronomical stations, it must be very desirable to be enabled to form some idea of the extent of error to which the predicted track of the central line may be subject. On this account I have made a further direct calculation for the Siamese capital, taking the moon's position from the American Ephemeris, in which the Tables of Prof. Peirce are employed. With elements thus modified, the partial phase is found to commence at oh. 50m. 42s., or 24 seconds only earlier than by Hansen's Tables; totality begins at 2h. 13m. 32s., and continues 3m. 59s. Generally I may remark that between the longitudes of the Nicobars and Siam, the track of central line by the American Tables has about five minutes greater latitude than that given by Hansen's Tables.

"(For any point in Siam in the neighbourhood of Bangkok, the *Greenwich* time of commencement of the partial eclipse will be given closely by the following formula:—

$$\begin{aligned} \cos. w &= -0.08471 - [0.12053] \sin. l + [0.12430] \cos. l, \cos. (L - 172^\circ 10' 11'') \\ l &= 18h. 55m. 58s. - [3.71146] \sin. w + [3.83098] \sin. l \\ &\quad - [3.83692] \cos. l, \cos. (L - 4^\circ 14' 5'') \end{aligned}$$

The *Greenwich* mean time of beginning and ending of totality may be found from

$$\begin{aligned} \cos. w &= -17.5228 - [1.74616] \sin. l + [1.68499] \cos. l, \cos. (L - 150^\circ 25' 5'') \\ l &= 18h. 17m. 58.5s. \mp [2.09477] \sin. w + [3.77348] \sin. l \\ &\quad - [3.84594] \cos. l, \cos. (L + 16^\circ 32' 8''). \end{aligned}$$

"In the above formulæ L expresses the east longitude of the point from Greenwich, taken positive; l is its geocentric latitude, and the quantities within the square brackets are logarithms. Upper sign for beginning of totality, lower sign for ending.)

"It has been stated above that the eclipse of next April may probably be the most favourable for observation that can take place during the present century. In the eclipse of 1878, July 29, the duration of totality is shorter, and the same is the case in the eclipses of 1882, 1887, 1900, &c. In the eclipse of 1886, August 29, the only easily accessible and favourable station appears to be the Island of Grenada, in the West Indies, where the duration of total eclipse is 3m. 15s., commencing at 7h. 10m. A.M. local time, with the sun at an altitude of 20°; thence the course of the central line is over the North and South Atlantic Oceans, to a point on the African coast north of St. Philip de Benguela. In the eclipse of 1892, April 26, the central line appears to have a sea-track through nearly its whole extent, if indeed it touches land at any point, which requires a more precise computation than I have yet made to determine. The eclipse of 1893, April 16, is the only one that can compare favourably, as regards length

of totality and track, with that of the present year: at a point in the vicinity of Ceara, in the Brazils, the duration of total eclipse is 4m. 44s. with the sun at an altitude of 76°."

We may conclude our article by stating that the observations for which the Council of the Royal Society have obtained a promise of a grant in aid amounting to 1,000*l.* will be limited to photographing the spectra of the chromosphere and coronal atmosphere.

For this purpose a siderostat has been placed at the disposal of the Royal Society, and another will be ready in time. These instruments have been made by Messrs. Cooke and Sons, of York, who have in some respects, with their usual skill, improved upon Foucault's model. As an instance of international courtesy which must not be unrecorded, we may state that M. Leverrier would have placed the original instrument devised by Foucault himself, and now at the Paris Observatory, at the disposal of the Royal Society, had it not been constructed solely for the latitude of Paris.

Besides siderostats, it is proposed that equatorials shall be sent out also, provided with apparatus for spectrum photography, quartz prisms and lenses being generally employed.

The Secretary of State for India (Lord Salisbury), the Viceroy of India, and the Admiralty officials are all hearty in their co-operation. It is hoped that Col. Tennant and a strong staff of assistants will also be on the scene of action.

Although the time is short, then, we may fairly hope that good work will be done. Of this we may be assured, that whether the observers be many or few, whether the weather be good or bad—and General Strachey considers the chances all that can be wished for—the action of the Royal Society and of the Government will redound to the credit of English science, and a bright page may be added to the scientific annals of our time.

EDITOR

COUNT RUMFORD'S COMPLETE WORKS

The Complete Works of Count Rumford. (Published by the American Academy of Arts and Sciences.)

THE American Academy of Arts and Sciences is doing good service and teaching the Old World a sound practical lesson by undertaking the publication of such a work as this. The question of what form should be given to the monument of a great man is often discussed, and fairly admits of much debating; but when the benefactor of humanity whose memory is to be preserved is one who has done the high service of extending the boundaries of science, we may safely venture to affirm that whatever *other* monuments may be erected, the *first* should be a complete and carefully compiled record of all his researches. The demand for this arises from the manner in which the results of original scientific work are usually communicated to the world, *i.e.* in the form of papers read before learned societies or contributed to magazines, or published as pamphlets, and thus scattered far and wide and liable to be forgotten or even altogether lost. Such a publication should precede all other forms

of memorial on the simple principle that strict justice should precede generosity. The object being to perpetuate and honour the memory of such a man, the first step should be to do *justice* to his memory, and this cannot be done unless his works are collected in an available and presentable form. The most perfect of monumental epitaphs is Sir Christopher Wren's in St. Paul's Cathedral—

"Lector, si monumentum requiris, circumspice."

A handsomely printed record of the life-work of any original investigator might bear a similar inscription. The justice of such an epitaph would be absolutely complete.

That Count Rumford himself took this view of the matter is evident from the fact that on recovering from the illness which in 1793-94 nearly finished his career, he left Bavaria and came to London in September 1795 for the purpose of publishing a collection of these same essays which the American Academy have now reprinted, and that he left London in 1802 when their publication was completed. His narrow escape from death had evidently suggested the necessity of losing no more time in thus doing justice to his own memory.

But it is not every scientific investigator who finds an appreciative monarch, like the Elector of Bavaria, willing to reward so munificently the services of intellect; there are but few who can afford to indulge in the expensive luxury of printing books which the uneducated millions and the ill-educated thousands are equally incapable of appreciating. The professional publisher is prohibited from undertaking such work, from the simple fact that much activity in that direction would land him in the Bankruptcy Court. Here, then, is a clear demand for uncommercial effort, if the memory of great men is to be preserved and the full advantages of their labour are to be reaped by their fellow-creatures.

We should do well here in England by at once commencing a great national effort in this direction. Local patriotism would be appropriately directed by starting the subscription for a republication fund in every town or village which has the honour of having given birth to a worthy worker in science; and our learned societies might carry out the work as the American Academy has done in this case. Birmingham has done well in erecting the noble statue of Priestley that fitly decorates the approach to the Birmingham and Midland Institute; but the student who admires the sculptured presentation of the great philosopher performing his great experiment has considerable difficulty in finding the full original record of this scientific exploit. How very interesting to the general student, either of science or of human nature, would be a complete collection of all the far-scattered and diverse works of Priestley's powerful and wide-grasping intellect! At present they are practically buried. The same may be said of the majority of the inductive philosophers, from Horrocks, Gilbert, and Galileo, down to the name on the latest scientific obituary. Such collections of the works of our great philosophers would be a worthy complement to the Royal Society's invaluable index of scientific papers.

The following list of the subjects treated in the three volumes already published sufficiently indicates the variety of Rumford's work:—

A Method of determining the Velocity of Projectiles; Experiments to determine the Force of fired Gunpowder; Experiments with Cannon, and Improvements in Field Artillery; The Production of Air from Water; The Quantities of Moisture absorbed from the Air by various substances; The Propagation of Heat in Fluids; The Final Cause of the Saltiness of the Sea; Chemical Affinity and Solution, and the Mechanical Principle of Animal Life; The Propagation of Heat in various substances; The Source of the Heat which is excited by Friction; An Inquiry into the Weight ascribed to Heat; The Nature of Heat, and the Mode of its Communication; Experimental Investigations concerning Heat; Reflections on Heat; Historical Review of the various Experiments of the Author on the subject of Heat; Experiments and Observations on the Cooling of Liquids in Vessels of Porcelain, gilded and not gilded; Account of a curious Phenomenon observed on the Glaciers of Chamouni; New Experiments on the Temperature of Water at its Maximum Density; The Propagation of Heat in Liquids; Adhesion of the Particles of Water to each other; The slow Progress of the Spontaneous Mixture of Liquids; The Use of Steam as a vehicle for transporting Heat; The Means of increasing the Quantities of Heat obtained in the Combustion of Fuel; Description of a New Boiler; The Use of the Heat of Steam in the making of Soap; Experiments on Wood and Charcoal; Heat developed in the Combustion and in the Condensation of Vapours; The Capacity for Heat of various Liquids; The Structure of Wood, &c.; Chimney Fireplaces; the Management of Fire, and the Economy of Fuel; The Construction of Kitchen Fireplaces and Kitchen Utensils; The various Processes of Cookery, and Proposals for improving that most useful art; The Management of Fires in closed Fireplaces.

One remarkable feature of Count Rumford's papers is their simplicity and clearness. They are all readable, to the least initiated in scientific technicalities. There is no pedantry, no vain display of unnecessary formulæ; but, on the contrary, every page displays the clear and purely scientific intellect of the writer. It matters not whether he is discussing the proper shape of a saucepan lid, the flavouring properties of a red herring, or the deepest mysteries of molecular force; whether he describes his method of eating a plate of hot pudding, or of reorganising and commanding the Bavarian army—the same thoroughness and simplicity of pure inductive and deductive reasoning prevails. He seems to have been incapable of thinking of any subject other than systematically and scientifically; and to this fixed habit of mind his marvellous success in the solution of the most difficult social and military problems is clearly traceable. His last effort, the essay on "The Nature and Effects of Order," upon which he laboured so long during the last years of his fading life, and which the feebleness of his over-tired intellect prevented him from finishing, was apparently intended as a vindication of his peculiarly strict and systematic method of doing everything, which was so miserably misunderstood by his eulogist Cuvier, his intensely French wife, and the Frenchmen by whom he was surrounded and ridiculed during his latter days. To do such work as Rumford achieved, and do it all so coolly without any sentimental flourishes, without drums, or flags,

or processions, or trumpets, or inaugurations, was to them quite incomprehensible, and hence their misrepresentation of his work and character, when they tell us that he looked upon mankind merely as objects of experiment, and not with any philanthropic feeling, and that "*il ne s'agissait que de nourrir les ouvriers assez bien pour entretenir cher eux la force musculaire des membres.*" Those portions of his essays in which he describes the work done at the "House of Industry" in Munich utterly refute these mistaken views of Rumford's character.

I have read nothing more humiliating in reference to the still remaining magnitude of popular ignorance of the merest rudiments of physical science than some of these essays. Take as an example this passage on page 177 of vol. ii. "The waste of fuel in culinary processes, which arises from making fluids boil *unnecessarily*, or when nothing more would be necessary than to keep them *boiling hot*, is enormous. I have no doubt but that much more than half the fuel used in all our kitchens, public and private, in the whole world, is wasted precisely in this manner." Again, he tells all the world that "nothing is so ill-judged as most of those attempts that are so frequently made by ignorant projectors *to force the same fire to perform different services at the same time.* The heat generated in the combustion of fuel is a *given quantity*, and the more *directly* it is applied to the object on which it is employed so much the better, for less of it will escape or be lost on the way; and what is taken away on one side for a particular purpose can produce no effect whatever on the other side where it is not."

These, and quite a multitude of similarly simple and obvious applications of the elementary laws of heat, were not only expounded but practically applied by Rumford eighty or ninety years ago, and we are still blundering on and blindly violating them. Every laundry is still filled with the steam of wastefully boiling coppers, and almost every saucepan in the United Kingdom and elsewhere is wastefully used for the unnecessary distillation of water, not one cook in 500 knowing that water is no hotter when it boils violently than when it "simmers" gently. Nine-tenths of the ranges exhibited at the last Exhibition of South Kensington were constructed in direct violation of the simple and obvious principles above stated, and our ironmongers still persist in making "kitcheners," "ranges," &c., with the fire in the middle, the oven on one side, and a boiler on the other, or even with ovens on both sides; instead of placing the fire on one side, the oven next, and boiler beyond, to utilise residual heat. In most of our best English houses a range capable of cooking for a dinner party of thirty or forty people is kept going to supply water for a tumbler of toddy, although Rumford demonstrated again and again the vast economy and convenience of having several fires in every establishment where the demands for cooking are variable, and his essays give descriptions and drawings of how these fires should be arranged.

It must be remembered that Rumford was no mere theoretical writer or lecturer, but he practically carried out on large and small scale every principle he expounds. He cooked for thousands and tens of thousands in his military kitchens, his House of Industry, in private houses, at the Foundling Hospital in London, at public institutions in Dublin, Edinburgh, &c.; and in these practical

demonstrations weighed his fuel, registered its consumption, and published the results.

Thus, at the Foundling Hospital he roasted 112 lbs. of beef with 22 lbs. of coal, the residual heat from the roaster going on to the boiler. In the public kitchen at Munich, where his arrangements were fully carried out, he frequently—as certified by the Colonel and Councillor of War—prepared the ordinary hot dinner for one thousand persons, and "the expense for fuel has not amounted to quite twelve kreutzers" (less than $4\frac{1}{2}d.$, or one-fiftieth of a farthing for each person). It must be remembered, in reference to this, that Rumford's soup requires five hours' boiling, or rather heating at the boiling-point.

I have little doubt that the merited failure of all the recent competitors for the Society of Arts' prize was due to the absence of scientific knowledge, and of that systematic inductive method of proceeding by the aid of which Rumford wedded theory to practice, and brought forth such important results. His researches on the "Propagation of Heat in Fluids," upon which our present knowledge of the phenomena of the convection of heat is mainly founded, were suggested by burning his mouth with a spoonful of thick rice soup, and were further elaborated in order to determine the best material for soldiers' clothing. His celebrated demonstration of the immateriality of heat was in like manner a result of cannon-boring. Every essay in these three volumes supply similar illustrations of the action and reaction of theory and practice upon each other, and their mutual development thereby.

One of the most curious and least-known of his speculative efforts is that upon "the mechanical principle of animal life." They bear upon many of the molecular speculations now occupying so much attention, and are sufficiently interesting to demand full quotation of the following essential paragraphs:—

"Suppose an open vessel—as a common glass tumbler, for instance—containing a piece of money, a small pebble, or any other small solid opaque body, to be filled with water and exposed in a window, or elsewhere, to the action of the sun's rays. As a ray of light cannot fail to generate heat when and where it is stopped or absorbed, the rays, which, entering the water and passing through it, impinge against the small solid opaque body at the bottom of the vessel, and are *there absorbed*, must necessarily generate a certain quantity of heat, a part of which will penetrate into the interior parts of the solid, and a part of it will be communicated to those colder particles of the water which repose on its surface.

"Let us suppose the quantity of heat so communicated to one of the integrant particles of the water to be so small that its effect in diminishing the specific gravity of the particle is but just sufficient to cause it to move upwards in the mass of the liquid with the very smallest degree of velocity that would be perceptible to our organs of sight were the particle in motion large enough to be visible. This would be at the rate of about *one hundredth part of an inch* in a second.

"This velocity, though it appears to be slow in the extreme when we compare it with those motions that we perceive among various bodies by which we are surrounded, yet we shall be surprised when we find what a rapid succession of events it is capable of producing.

"If we suppose the diameter of the integrant particles or *molecules* of water to be *one-millionth part of an inch* (and it is highly probable that they are even less), in that case it is most certain that an individual particle, moving

in a quiescent part of that fluid with the velocity in question, would run through a space equal to *ten thousand times the length of its diameter in one second*, and consequently would come into contact with at least *six hundred thousand* different particles of water in that time.

"Hence it appears how inconceivably short the time must be that an individual particle, in motion, of any fluid can remain in contact with any other individual particle, not in motion, against which it strikes in its progress, however slow that progress may appear to us to be through the quiescent mass of the fluid!

"Supposing the contact to last as long as the moving particle employs in passing through a space equal to the length of its diameter—which is evidently all that is possible, and more than is probable—then, in the case just stated, the contact could not last longer than $\frac{1}{10000}$ part of a second! This is the time which the cannon bullet, flying with its greatest velocity (that of 1,600 ft. per second), would employ in advancing two inches.

"If the cannon bullet be a *nine-pounder*, its diameter will be four inches, and if it move with a velocity of 1,600 feet in a second, it will pass through a space just equal to 4,800 times the length of its diameter in one second. But we have seen that a particle of water moving $\frac{1}{1000}$ of an inch in a second actually passes through a space equal to 10,000 times the length of its diameter in that time. Hence it appears that *the velocity with which the moving body quits the space it occupies* is more than twice as great in the particle of water as in the cannon bullet!"

I am sorry that space does not permit further quotation of this essay, in which the author goes on to show that inequality of fluid temperature is one of the leading phenomena of animal life; that respiration raises the heat in one part, while insensible perspiration cools another; that stimulation of all kinds is accompanied with disturbance of temperature and the consequent motion of particles, which he regards as the life of fluids.

Of course it is not supposed that Rumford, by these ingenious speculations, supplies any mechanical solution of the mystery of *conscious* vitality, but his suggestions have the merit of showing that a vast amount of molecular activity is a demonstrable result of simple well-known facts. He obtains this activity without invoking the aid of those profound assumptions in which the brilliant imaginations of modern mathematicians so luxuriously revel when they reason upon the vibrations, gyrations, &c., of the component particles of interatomic atmospheres.

In spite of all the progress we have made in physical science, these essays, written for the most part during the last century, contain a great deal that is still suggestive and worthy of thoughtful reading both by popular students and experts in physical and social science. This is especially the case in the essay on "The Propagation of Heat in Fluids," reprinted in vol. i. of this work. Many of the conclusions and speculations are now demonstrably erroneous, but some of the suggestions—more particularly those in chap. iii. on the Chemical Action of Light—are worthy of far more attention and investigation than they have yet received. They are avowedly very bold, but the author tells us frankly that their temerity "has not been entirely without design;" that "philosophers may be *enticed* and they may be *provoked* to action," and that he has "endeavoured to use both these methods," even with conscious imprudence, for the purpose of ex-

citing them to further investigation of the subjects for which he has such "passionate fondness."

It will be well if the republication of these essays contribute to the fulfilment of Rumford's enthusiastic wishes.

W. MATTIEU WILLIAMS

THE SILKWORM COCOON

Le Cocon de Soie. Histoire de ses transformations, description des races civilisées et rustiques, production et distribution géographiques, maladies des vers à soie, physiologie du cocon et du fil du soie. Deuxième Edition. (Paris: J. Rothschild, 1875.)

WE have received an advance copy of M. E. Duseigneur-Kléber's monograph, "Le Cocon de Soie," dated for 1875, the get-up of which is calculated at once to arrest attention and excite interest. The 248 quarto pages of clearly printed letterpress containing his information, admirably arranged in methodic form, are accompanied by thirty-seven plates executed in photo-typography, and a map of the world indicating the localities where silkworms are cultivated. Twenty-eight of the plates are devoted to the illustration of the different types of cocoons from different countries, of which as many as 195 are figured from photographs.

Such a work was, he says, quite impossible twenty years ago, and it is only in consequence of diseases that it is possible now. Each district prided itself on the silk it produced, and did not trouble to know what other countries were doing, until the enfeeblement of some and the destruction of other types by disease compelled growers to seek fresh types from a distance, and thus accumulated the information which M. Duseigneur-Kléber has compiled and presented in this attractive form. Many of the types he thinks will probably not be again met with in cultivation, and it is only through noticing and recording facts as they came under his notice during a series of years that his information has been obtained. Looking to the past, he finds that from 1700 the years of disease were 1702, 1720, 1750, 1787, but the chroniclers give no intimation of the character of the disease. In 1810 the "plague" was described by M. Paroletti. The affected worm exhibited small spots all over its body, which were gangrenous, and appeared to be caused by the same disease now known as "Muscardine."

Among the practical points noticed in the first section of the work are the following: That the red or black mulberry produces more vigorous worms than the white; that the old notion of selecting bright-coloured cocoons for breeding has given place to the belief that dull yellow are the best; that the practice of limiting the time of copulation of moths is injurious; that while the worms are making their cocoons, the ventilation of the buildings, too often neglected, is even more important than warmth. The symptoms of the disease known as Pebrine are detailed, but its cause seems to be not known. That its recurrence coincides with unusually wet and cold seasons is established, but whether it results from a parasitic vegetation whose germs are carried in the air is still a subject for experiment. When the external indications are well marked, the silk reservoir is found much diminished in volume. The spots which appear on the skin continue